CLAIMS

1. An energy absorbing assembly, comprising:

a rigid support structure having at least one inlet;

a flexible covering engaged with the rigid support structure to define an expandable interior region;

a fluid source in fluid communication with the at least one inlet; and

a shape memory foam disposed in the expandable interior region, wherein the shape memory foam is adapted to expand to an expanded configuration in response to the fluid communication with the fluid source.

2. The energy absorbing assembly of Claim 1, further comprising means for heating the shape memory foam in the expanded configuration.

3. The energy absorbing assembly of Claim 1, further comprising a crash sensor and a pressure sensor in electrical communication with a controller, wherein the controller is in operative communication with the at least one inlet, and wherein the pressure sensor is adapted to monitor a pressure within the interior region.

4. The energy absorbing assembly of Claim 1, wherein the shape memory foam is a material selected from the group consisting of a shape memory polymer and a shape memory alloy.

5. The energy absorbing assembly of Claim 4, wherein the shape memory alloy comprises nickel-titanium based alloys, indium-titanium based alloys, nickel-aluminum based alloys, nickel-gallium based alloys, copper based alloys, gold-cadmium based alloys, iron -platinum based alloys, iron-palladium based alloys, silver-cadmium based alloys, indium-cadmium based alloys, manganese-copper based alloys, or combinations comprising at least one of the foregoing alloys.

6. The energy absorbing assembly of Claim 4, wherein the shape memory polymer comprises polyphosphazenes, poly(vinyl alcohols), polyamides, polyester amides, poly(amino acid)s, polyanhydrides, polycarbonates, polyacrylates, polyalkylenes, polyacrylamides, polyalkylene glycols, polyalkylene oxides, polyalkylene terephthalates, polyortho esters, polyvinyl ethers, polyvinyl esters, polyvinyl halides, polyesters, polylactides, polyglycolides, polysiloxanes, polyurethanes, polyethers, polyether amides, polyether esters, poly(methyl methacrylate), poly(ethyl methacrylate), poly(butyl methacrylate), poly(isobutyl methacrylate), poly(hexyl methacrylate), poly(isodecyl methacrylate), poly(lauryl methacrylate), poly(phenyl methacrylate), poly(methyl acrylate), poly(isopropyl acrylate), poly(isobutyl acrylate) and poly(octadecyl acrylate), polystyrene, polypropylene, polyvinyl phenol, polyvinylpyrrolidone, chlorinated polybutylene, poly(octadecyl vinyl ether), ethylene vinyl acetate, polyethylene, poly(ethylene oxide)-poly(ethylene terephthalate), polyethylene/nylon (graft copolymer), polycaprolactones-polyamide (block copolymer), poly(caprolactone) dimethacrylate-n-butyl acrylate, poly(norbornyl-polyhedral oligomeric silsequioxane), polyvinylchloride, urethane/butadiene copolymers, polyurethane block copolymers, styrene-butadiene-styrene block copolymers, or copolymers thereof.

7. The energy absorbing assembly of Claim 1, wherein the rigid support structure comprises a vehicle door pillar, a vehicle header, a vehicle door interior, a vehicle dashboard, a sun visor, an armrest, a vehicle knee bolster, a vehicle floor, a vehicle headrest, a vehicle seat, or a vehicle seat back.

8. The energy absorbing assembly of Claim 1, wherein the flexible covering sealingly engaged with the rigid support structure defines multiple expandable interior regions, wherein each one of the multiple inflatable interior regions includes the at least one inlet and shape memory foam.

9. The energy absorbing assembly of Claim 1, wherein the fluid source comprises a pressurized gas canister or an accumulator inflator or a pyrotechnic device.

10. The energy absorbing assembly of Claim 1, wherein the fluid source comprises a gas or a liquid.

11. An interior vehicle surface comprising:

an energy absorbing assembly comprising a rigid support structure having at least one inlet; a flexible covering engaged with the rigid support structure to define an expandable interior region; a fluid source in fluid communication with the at least one inlet; and a shape memory foam disposed in the expandable interior region, wherein the shape memory foam is adapted to expand to an expanded configuration in response to the fluid communication with the fluid source.

12. The interior vehicle surface of Claim 12, wherein the energy absorbing assembly forms a door pillar surface, a headrest surface, a floor surface, a seat surface, a dashboard surface, a steering wheel surface, a door surface, a ceiling surface, header, roof rail, center console, or a combination comprising at least one of the foregoing interior vehicle surfaces.

13. The interior vehicle surface of Claim 12, wherein the shape memory foam is a material selected from the group consisting of a shape memory polymer and a shape memory alloy.

14. The energy absorbing assembly of Claim 12, wherein the shape memory alloy comprises nickel-titanium based alloys, indium-titanium based alloys, nickel-aluminum based alloys, nickel-gallium based alloys, copper based alloys, gold-cadmium based alloys, iron -platinum based alloys, iron-palladium based alloys, silver-cadmium based alloys, indium-cadmium based alloys, manganese-copper based alloys, or combinations comprising at least one of the foregoing alloys.

15. The interior vehicle surface of Claim 12, wherein the shape memory polymer comprises polyphosphazenes, poly(vinyl alcohols), polyamides, polyester amides, poly(amino acid)s, polyanhydrides, polycarbonates, polyacrylates, polyalkylenes, polyacrylamides, polyalkylene glycols, polyalkylene oxides, polyalkylene terephthalates, polyortho esters, polyvinyl ethers, polyvinyl esters, polyvinyl halides, polyesters, polylactides, polyglycolides, polysiloxanes, polyurethanes, polyethers, polyether amides, polyether esters, poly(methyl methacrylate), poly(ethyl methacrylate), poly(butyl methacrylate), poly(isobutyl methacrylate), poly(hexyl methacrylate), poly(isodecyl methacrylate), poly(lauryl methacrylate), poly(phenyl methacrylate), poly(methyl acrylate), poly(isopropyl acrylate), poly(isobutyl acrylate) and poly(octadecyl acrylate), polystyrene, polypropylene, polyvinyl phenol, polyvinylpyrrolidone, chlorinated polybutylene, poly(octadecyl vinyl ether), ethylene vinyl acetate, polyethylene, poly(ethylene oxide)-poly(ethylene terephthalate), polyethylene/nylon (graft copolymer), polycaprolactones-polyamide (block copolymer), poly(caprolactone) dimethacrylate-n-butyl acrylate, poly(norbornyl-polyhedral oligomeric silsequioxane), polyvinylchloride, urethane/butadiene copolymers, polyurethane block copolymers, styrene-butadiene-styrene block copolymers, or copolymers thereof.

16. A method of operating an energy absorbing assembly, comprising:

attaching the energy absorbing assembly to a rigid support structure, wherein the energy absorbing assembly comprises a flexible covering engaged with the rigid support structure to define an expandable interior region; a fluid source in fluid communication with the at least one inlet; and a shape memory foam disposed in the expandable interior region, wherein the shape memory foam is adapted to expand to an expanded configuration in response to the fluid communication with the fluid source;

expanding the shape memory foam from a permanent shape to the expanded configuration with the fluid source at a temperature less than a transition temperature of the shape memory foam; and

heating the shape memory foam above the transition temperature causing the shape memory foam to revert back to the permanent shape, wherein the permanent shape has a density greater than the expanded configuration.

17. The method of operating the energy absorbing assembly of Claim 16, wherein the shape memory foam is a material selected from the group consisting of a shape memory polymer and a shape memory alloy.

18. The energy absorbing assembly of Claim 17, wherein the shape memory alloy comprises nickel-titanium based alloys, indium-titanium based alloys, nickel-aluminum based alloys, nickel-gallium based alloys, copper based alloys, gold-cadmium based alloys, iron -platinum based alloys, iron-palladium based alloys, silver-cadmium based alloys, indium-cadmium based alloys, manganese-copper based alloys, or combinations comprising at least one of the foregoing alloys.

19. The energy absorbing assembly of Claim 17, wherein expanding the shape memory foam from a permanent shape to the expanded configuration is at a temperature less than a martensite to austenite transition temperature for the shape memory alloy, and wherein heating the shape memory foam is at a temperature greater than the martensite to austenite transition temperature.

20. The method of operating the energy absorbing assembly of Claim 17, wherein the shape memory polymer comprises polyphosphazenes, poly(vinyl alcohols), polyamides, polyester amides, poly(amino acid)s, polyanhydrides, polycarbonates, polyacrylates, polyalkylenes, polyacrylamides, polyalkylene glycols, polyalkylene oxides, polyalkylene terephthalates, polyortho esters, polyvinyl ethers, polyvinyl esters, polyvinyl halides, polyesters, polylactides, polyglycolides, polysiloxanes, polyurethanes, polyethers, polyether amides, polyether esters, poly(methyl methacrylate), poly(ethyl methacrylate), poly(butyl methacrylate), poly(isobutyl methacrylate), poly(hexyl methacrylate), poly(isodecyl methacrylate), poly(lauryl methacrylate), poly(phenyl methacrylate), poly(methyl acrylate), poly(isopropyl acrylate), poly(isobutyl acrylate) and poly(octadecyl acrylate), polystyrene, polypropylene, polyvinyl phenol, polyvinylpyrrolidone, chlorinated polybutylene, poly(octadecyl vinyl ether), ethylene vinyl acetate, polyethylene, poly(ethylene oxide)-poly(ethylene terephthalate), polyethylene/nylon (graft copolymer), polycaprolactones-polyamide (block copolymer), poly(caprolactone) dimethacrylate-n-butyl acrylate, poly(norbornyl-polyhedral oligomeric silsequioxane), polyvinylchloride, urethane/butadiene copolymers, polyurethane block copolymers, styrene-butadiene-styrene block copolymers, or copolymers thereof.

21. The method of operating the energy absorbing assembly of Claim 20, wherein expanding the shape memory foam from a permanent shape to the expanded configuration is at a temperature less than a glass transition temperature for the shape memory polymer, and wherein heating the shape memory alloy is at a temperature greater than the glass transition temperature.

22. The method of operating the energy absorbing assembly of Claim 16, further comprising cooling the shape memory foam to a temperature below the transition temperature causing the shape memory foam to revert back to a permanent shape from the expanded configuration.

23. The method of operating the energy absorbing assembly of Claim 16, further comprising recharging the fluid source.

24. A method of operating an energy absorbing assembly, comprising:

sensing an impact of an object;

expanding a shape memory foam disposed within the vehicle interior surface from a trained shape to an expanded shape;

absorbing the impact of the object with the expanded shape of the shape memory foam; and

heating the shape memory foam above a transition temperature causing the shape memory foam to revert back to the trained shape, wherein the trained shape has a density greater than the expanded configuration.

25. The method of operating the energy absorbing assembly of Claim 24, wherein the shape memory foam is a material selected from the group consisting of a shape memory alloy and a shape memory polymer.

26. The method of operating the energy absorbing assembly of Claim 25, wherein the shape memory alloy comprises nickel-titanium based alloys, indium-titanium based alloys, nickel-aluminum based alloys, nickel-gallium based alloys, copper based alloys, gold-cadmium based alloys, iron -platinum based alloys, iron-palladium based alloys, silver-cadmium based alloys, indium-cadmium based alloys, manganese-copper based alloys, or combinations comprising at least one of the foregoing alloys.

27. The method of operating the energy absorbing assembly of Claim 25, wherein the transition temperature comprises a martensite to austenite transition.

28. The method of operating the energy absorbing assembly of Claim 25, wherein the shape memory polymer comprises polyphosphazenes, poly(vinyl alcohols), polyamides, polyester amides, poly(amino acid)s, polyanhydrides, polycarbonates, polyacrylates, polyalkylenes, polyacrylamides, polyalkylene glycols, polyalkylene oxides, polyalkylene terephthalates, polyortho esters, polyvinyl ethers, polyvinyl esters, polyvinyl halides, polyesters, polylactides, polyglycolides,

polysiloxanes, polyurethanes, polyethers, polyether amides, polyether esters, poly(methyl methacrylate), poly(ethyl methacrylate), poly(butyl methacrylate), poly(isobutyl methacrylate), poly(hexyl methacrylate), poly(isodecyl methacrylate), poly(lauryl methacrylate), poly(phenyl methacrylate), poly(methyl acrylate), poly(isopropyl acrylate), poly(isobutyl acrylate) and poly(octadecyl acrylate), polystyrene, polypropylene, polyvinyl phenol, polyvinylpyrrolidone, chlorinated polybutylene, poly(octadecyl vinyl ether), ethylene vinyl acetate, polyethylene, poly(ethylene oxide)-poly(ethylene terephthalate), polyethylene/nylon (graft copolymer), polycaprolactones-polyamide (block copolymer), poly(caprolactone) dimethacrylate-n-butyl acrylate, poly(norbornyl-polyhedral oligomeric silsequioxane), polyvinylchloride, urethane/butadiene copolymers, polyurethane block copolymers, styrene-butadiene-styrene block copolymers, or copolymers thereof.

29. The method of operating the energy absorbing assembly of Claim 28, wherein the transition temperature comprises a glass transition.

30. The method of operating the energy absorbing assembly of Claim 23, further comprising cooling the shape memory foam to a temperature below the transition temperature causing the shape memory foam to revert back to the trained shape from the expanded shape.

31. The method of operating the energy absorbing assembly of Claim 24, further comprising recharging the fluid source.